1. When we studied *uniform* circular motion on pages 67-69 we found that the angle between the object's velocity and its acceleration is always _______________ 90 degrees *if* the object's speed is ___________. (more than, less than, equal to.... increasing, decreasing, constant)

2. In the trajectory exercise on page 70 we found that when the object was coasting diagonally upward the angle between the its velocity and its acceleration was ______ than 90° if the vectors are placed tail-to-tail. In that example the object's speed was ___creasing.

3. The angles in #1 & 2 are not equal because the speed is ________ in #___ but ___creasing in #___. Please use the results above to fill in the blanks in #2 on RS VII.

4. On the back of this page draw the path of a pendulum bob swinging with moderate amplitude.
   a. If the string's length does not change, this path must be the type of curve known as a __________. (See #2 on page 42) Make a dot at a place on the curve where the bob is going diagonally upward, shortly after passing the lowest point.
   b. Draw and label a straight arrow from that dot to indicate the direction of the bob's velocity. *In geometric language it must be __________ to the curve, as in #11 on page 70 and 3a on p. 42.*
   c. Using #2 on RS VII, draw and label another arrow from the dot indicating (roughly) the direction of the bob's acceleration. Hint: If the speed were constant, this arrow would point ________ the center of the circle. (toward, from) Since the speed is *not* constant, it will point in a *slightly* different direction.
   d. The arrows that you made for 4b & 4c form an angle that is ______ than 90 degrees because the bob's speed is ___creasing as it coasts diagonally upward. Does #2 agree? __

5. Resolve the acceleration arrow in 4c into components parallel and perpendicular to the bob's velocity, as on page 41b. (The vector sum of those two components must be the acceleration.)
   a. The perpendicular component is called "____________al" acceleration because it points toward the _________ of the circular path. (Copy the words from RS VII.)
   b. The other component is called "tangential" acceleration, because it is parallel to the ______ line that you drew in 4b. It points in the _________ direction (uphill, downhill) because gravity is causing the bob's speed to ___crease while coasting in the ____hill direction.

6. The __________al part of the object's acceleration is zero as it passes the lowest point on the curved path, so its acceleration must then be in the __________al direction as it was on pages 41, 42, & 67.

7. Sketch a velocity-time graph describing the bob's motion near an end point of the curve, where it stops moving in one direction and begins moving back:
   a. The graph shows that the bob's velocity must be ___________ at the end point.
   b. According to 3b on RS VII, the __________al acceleration is proportional to the speed squared.
   c. The ___________al component of acceleration must then be zero at the turnaround points.
   d. The object's acceleration at those points can only be in the __________al direction.
   e. Please illustrate #6 and 7d by drawing and labeling acceleration arrows at the lowest point and at the two turnaround points on a curved path like the one that you drew for #4. Make the amplitude less than 90 degrees.

8. Summary: If an object is moving along a curved path, its acceleration has two "components".
   a. The "centripetal" component is given by the formula in #___ on RS VII: a = ________
   b. The other part is in a _________al direction. It's *backward* if the speed is ___creasing.
   c. It's *forward* if the speed is ___creasing, as when a pendulum bob coasts _____hill.
   d. Does 8c contradict 5b? ___

1. Using at least half a sheet of paper, sketch the path or "trajectory" of an object thrown horizontally so that it lands on the floor some distance away. Write the word "trajectory" along that curve. Make a dot at the point on that path where the object was released, and label it "O". Make another dot on the path at a point just *before* impact, and label it "P". Using a ruler, draw a straight arrow from O to P.
   a. Using the language of *geometry*, what kind of line is that? (Circle the best choice.)
      tangent chord diameter bisector radius baseline
   b. Which word from the language of *physics* best describes that arrow?
      displacement velocity mass momentum acceleration force
   c. Please copy the circled word from 1b onto your diagram. Write it along line OP.

2. Using a ruler and a pencil, lightly draw a line tangent to the curved path at point P. Write "tangent line" along that line. Then draw a small circle around point P. Imagine viewing that small region with a microscope. Which description below best fits the part of the trajectory which is inside that circle?
   (A) A vertical line.
   (B) A straight line crossing or intersecting the tangent line. (See page 29.)
   (C) A straight line coinciding with the diagonal tangent line.

3. Which arrow best describes the velocity with which the object moves through the small circle?
   Label that arrow, point P and the impact point in your enlarged illustration. Don't contradict 1b or 2.
   (A) A vertical arrow crossing the diagonal path at P.
   (B) A diagonal arrow along the tangent line pointing away from the impact point, toward P.
   (C) A diagonal arrow along the tangent line pointing from P, toward the impact point.
   (D) An arrow through P in the same direction as OP.

4. A **trajectory** is the path followed by a thrown object. The object itself is called a **projectile.** (These words share the latin root, *ject*, which means "throw", as in "eject", "reject", "inject", and "subject".) A **simple trajectory** is the path followed by a projectile which is influenced by gravitational force *only*, with no significant air drag or propelling force. You had experience with simple trajectories in the experiment on page 63 and also on page 70. *Because the only significant force acting on such a projectile is _____ward and constant, the projectile's ___________ must be _____ward and ________.*

5. Imagine a brick thrown horizontally from a window ___ meters above the ground. It lands ___ meters _____ from the base of the building. *Choose two different reasonable numbers and a direction.*
   * a. Show how the brick's flight time is calculated. (Use the first trajectory principle with #22 on RS II.)
   * b. Using the second trajectory principle on RS V or RS VII, sketch a graph of horizontal velocity vs. time.
   * c. Use the data above to calculate the brick's initial velocity. *Also describe the direction of that velocity.*
   * d. Use the equations and graph in 5a to calculate the *vertical* component of its impact velocity.
   * e. You now have the horizontal and vertical components of the brick's impact velocity.
   Use them to determine the magnitude of that vector. Also describe its direction, as on page 34R.
   f. Did you write formulas for each part of 5a-5e to show *how* each result was calculated from the given quantities, and did you define the symbols in those formulas? ____ (If not, go back and do it now.)

6. Make a large sketch of the brick's "trajectory", i.e. the path followed by the brick in #5.
   a. Label the impact point. Draw a long, straight arrow through that dot, tangent to the curved path, to indicate the direction of the instantaneous velocity which the brick would have had at that point in the trip if it had not hit anything. Label it "V". *Try not to contradict 5e.*
   b. Near the diagram, write the definition of "displacement". Copy it from RSII or from page 16.
   Illustrate by drawing a dotted arrow on your diagram. Label it "D". Describe its direction, as on 34R.
   * c. Is the direction of the brick's impact velocity the same as the direction of its final displacement?
   d. The slope of the velocity arrow in 5e is ___ times the slope of the displacement arrow in 5b. Is that a coincidence? *If so, show that the ratio is different in another example. If not, prove the theorem.*
   e. Draw and label another arrow through the impact point to indicate the object's acceleration just before impact. *If you are not sure about the direction of that acceleration, think about what causes it.*
   f. If the acceleration and velocity arrows are tail-to-tail, the angle between them is _____ than 90^o because the object's speed is ___creasing. This handy fact is already recorded in #___ on RS VII.